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Digital crafts. Procedural design in education and research

Case study of Félix Candela

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Synopsis

"Procedural design is often classified as a computational approach relying upon a set of instructions that, when used in a particular sequence, are the generators of form".[1]

The present paper discusses the importance of the algorithm thinking in the Schools of Architecture and PhD students. Procedural design enhances a scientific and rigorous approach to develop research projects, and a systematic workflow to design architecture. Students need to focus in the logic and the process of the proposal rather than the final outcome or the form.

Traditionally, architects or designers had to learn different crafts of their profession in order to become an expert. Today, "those crafts are mostly digital."[2]

We present part of a research project which consisted in the virtual reconstruction of the non-built architecture of Félix Candela. The workflow was based in a computational approach to generate an automation process for the different families of projects designed by the architect.

Key words: Procedural design, education, geometry.

[1] AHLQUIST, Sean. (2016). Procedural Design. *Acadia 2016, Posthuman frontiers*. pp 10.
[2] JABI, Wassim. (2013). Parametric Design for Architecture. Laurence King. pp. 12.

1. Introduction

Paremetricism has received a lot of attention since Patrik Schumacher [3], partner at Zaha Hadid Architects, elevated the term to the level of an architectural movement. According to the author, the most important movement since Modernism.

Parametric architecture is a process based on algorithm thinking. Designers have to establish a relationship between different parameters and rules, as well as describe the logic and intent of the design.

It is ruled by parameters, which are not the same as variables. According to its etymological definition, the word parameter (para – next to; meter – measure) means something that is there to establish another measure. As opposed to a constant, a parameter can contain a range of values which enables a parametric design to vary around a logic and a procedure.

Parametric and algorithmic thinking is not about any piece of computer software or any one particular syntax, but about logic, geometry, topology and interaction[4] (fig 1).

Figure 1. Branching Morphogenesis. Ars Electronica Center, Digital Art Museum at Linz.

Procedural design establishes relationships between the parameters following an ordered definition through inputs and outputs, however, it goes further than a simple relation between parameters. “Procedural processes become an active agent for resolving the relationships of system” [5]. In addition, to design a system based in a process, students need to order their ideas with coherence, consistency and structure. Those are all important factors in a scientific approach for a research project, hence its importance in the training of PhD students.

[3] SCHUMACHER Patick (2008). Parametricism as a Style – Parametricism Manifesto. London 2008.
[4] JABI, Wassim. (2013). Parametric Design for Architecture. Laurence King. pp. 1.
[5] AHLQUIST, Sean. (2016). Procedural Design. *Acadia 2016, Posthuman frontiers*. pp 10.

2. Interdisciplinary education

We live in the digital era. The new crafts for designers are mostly digital and there is a growing interdisciplinary connection between different disciplines.

Automation, mass-customization, continuous differentiation, iteration… are terms frequently used in the software development field, now borrowed by the parametric architecture designers.

The industries of cinema and videogames have propitiated the development of specific hardware and software, which have greatly benefited the architecture industry.[6]

The scope of architecture, design and other careers and professions are closer than ever. Training needs a multidisciplinary approach that allows the student to specialize in an increasingly connected network.

“Sooner or later, I believe parametric design has to be explored through algorithmic thinking and that means that the designer needs to achieve a certain level of comfort with scripting languages. Once you learn the fundamentals of programming, the syntax becomes a far less difficult hurdle to overcome.”[7]

A methodology with a procedural design specifies a sequence based in a relation of different parameters. This approach could be used to design architecture, levels for videogames or a coded city plan for urbanism. It is the duty of the designer to addapt that procces to its requirements.

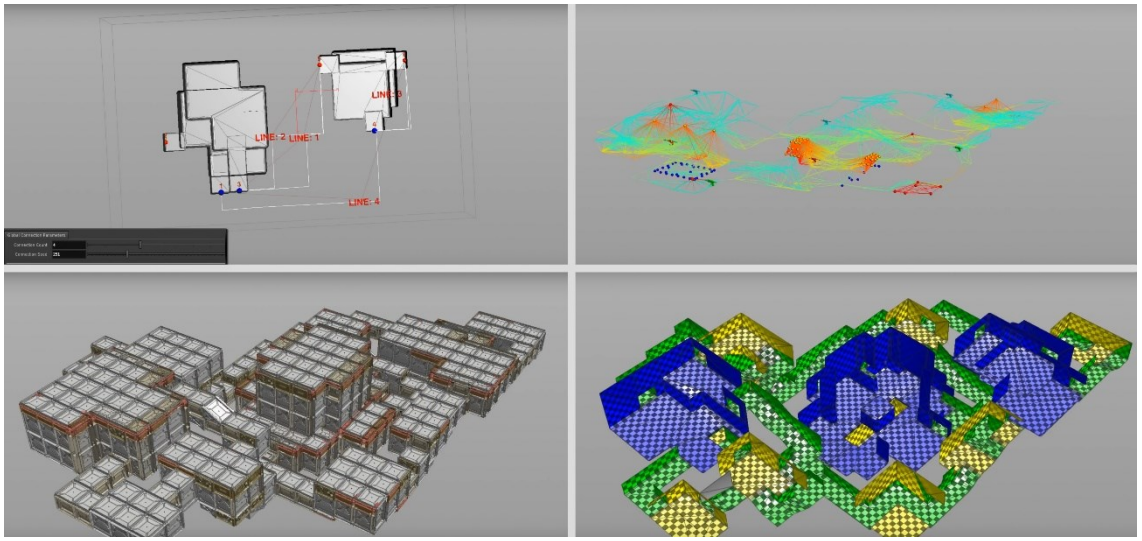

Figure 2. Procedural level design, Erwin Heyms, 2013.

Levels for videogames are frequently designed using a procedural design. In the example (figure 2), an architectonic space was defined by four different modules: landmark rooms, exists for the rooms, connections between the rooms with corridors and secondary volumes. The algorithm used allows to get multiple variations of the project, preserving the parameters that were firstly defined. A

[6] More detailed information can be found in: DEL BLANCO, Federico Luis; García, Ismael. Technology transfer: from Cine to Architecture. *Architectural Draughtsmanship, pp. 105 - 118*

[7] JABI, Wassim. (2016). Interview. Last visited February 2018. http://www.archsupply.com/parametric-design-for-architecture-wassim-jabi/

computational design presents multiple advantages, such as the possibility to analyze areas according to different parameters (in this case, dangerous zones). From the point of view of a procedural design, the same approach could be done from architecture students, adjusting the design to the discipline. The advantages of having multiple iterations from an initial design are not few, and the possibility of calculating simulations open new possibilities for a computational design of architecture.

One of the problems that we find with architecture students to develop this kind of projects, is the lack of knowledge that they have about scripting languages. Visual programming help in this regard. In a short term it simplifies the process to develop an algorithm thinking. Students with scripting knowledge could build their own personalized tools or extend the capabilities of existing software. The example in the figure 2 shows a project developed by students during a workshop. Students designed their own tools oriented to analyze terrains. The example shows a tool that automatically transforms heightmap information from the NASA database into the level curves of the terrain (figure 3).

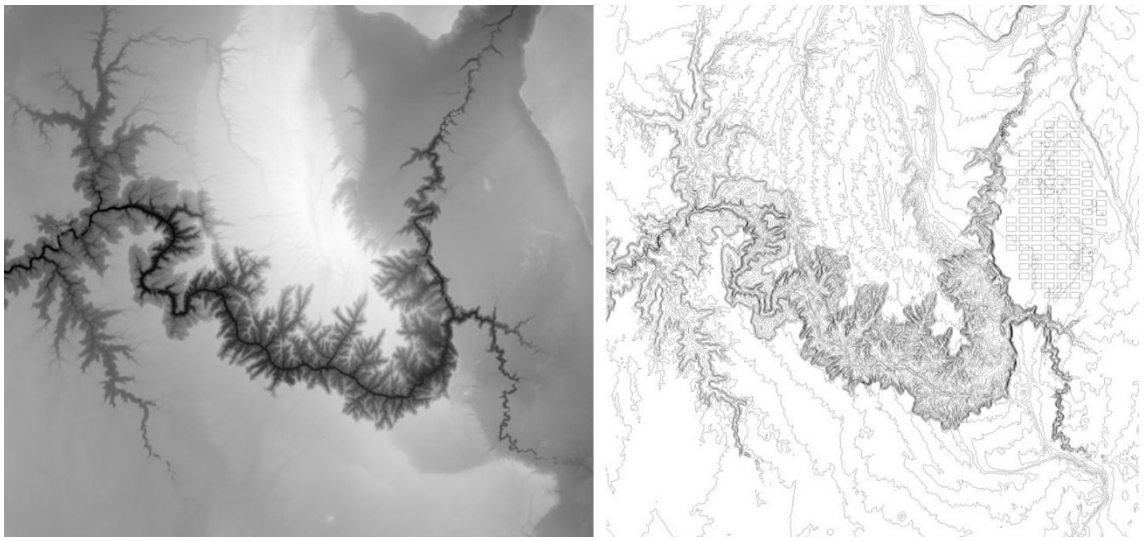

Figure 3. Terrains obtained automatically using a custom plugin.

The Mediated Matter research group at MIT directed by Neri Oxman (figure 4), conducts research at the intersection of computational design, digital fabrication, materials science and synthetic biology and apply that knowledge to design across scales from the micro scale to the building scale. For this purpose, the members of the lab have a variated interdisciplinary background, from architects to material engineers. Adding knowledge from different disciplines can open new research fields.

Figure 4. Chitosan based structures.

3. Procedural design for automation. Case study of the virtual reconstruction of Félix Candela non-built architecture

Procedural design offers many possibilities for researchers. In this communication we present a case based on automation. The project consisted in the virtual reconstruction of the non-built architecture of Felix Candela. After the collection of data and its preprocessing, the next step was to design different algorithms for the reconstruction of the projects, grouping them in different families of prototypes.

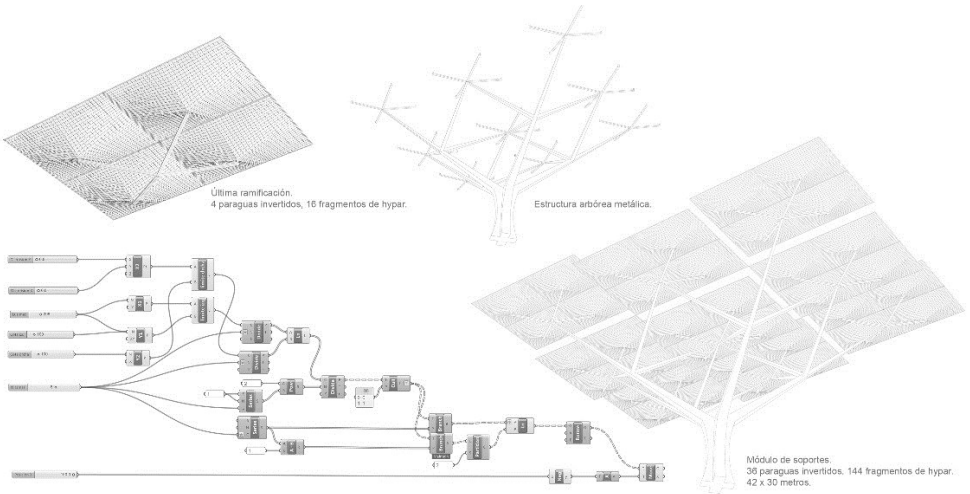

Figure 5. Variation of the inverted umbrela using a metallic structure. Images of the author.

The architecture of Félix Candela fits perfectly with this workflow, as he designed an initial constructive system, and applied multiple variations to it. The figures 5 and 6 shows the variations of the inverted umbrella adapted to different

projects.

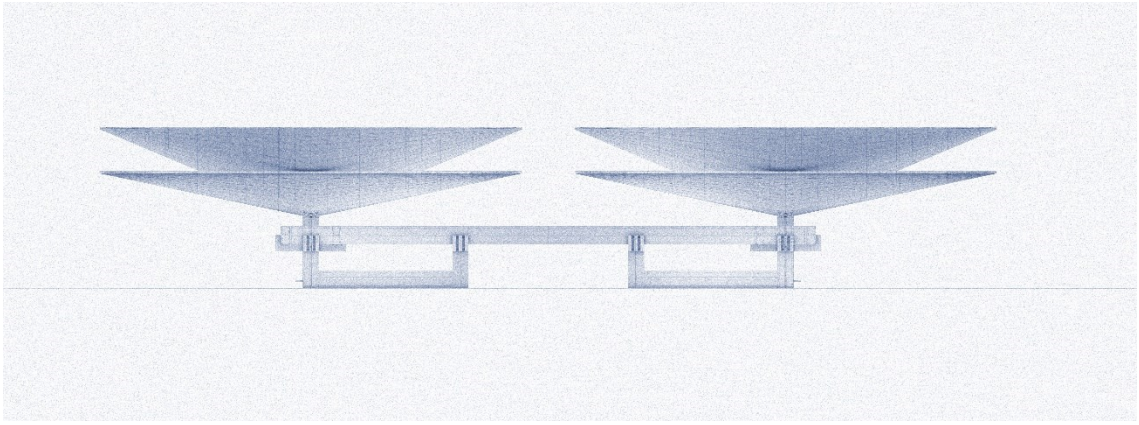

Figure 6. Variation of the inverted umbrella using the same definition. Images of the author.

The automation process allowed to produce 2.000 drawing for the documentation of the projects (figure 7). This amount of work would not have been possible using traditional techniques.

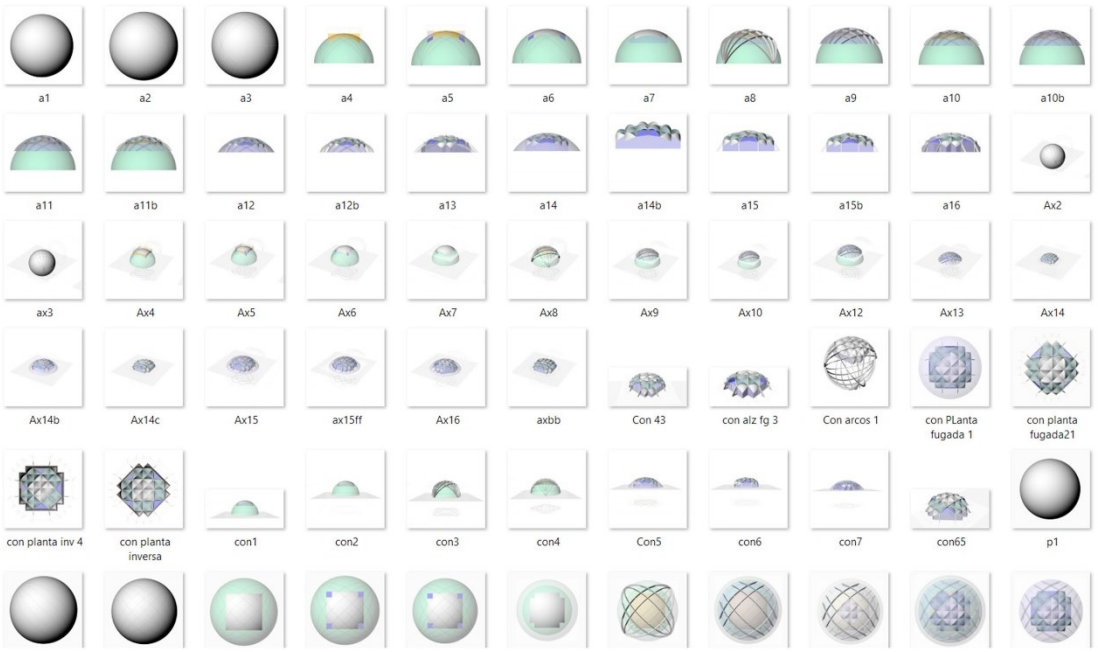

Figure 7. Generative process of one of the domes designed by Félix Candela. Images of the author.

4. Conclusions

Computational design is becoming more important in the industry of architecture. Students need an interdisciplinary background in order to achieve its potential and open new research lines related to design.

The results obtained under these circumstances are not only valid for a scientific point of view, but also academic.

Automated process can be designed for mass production, mass-customization, or simply to save time and man power in a project. However, to

design and implement an algorithm that allows for it, the student or researcher need to have enough knowledge of the digital tools, the new crafts.

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Biography

Federico Luis del Blanco García. PhD Architect at Polytechnic University of Madrid (2017), specialist in Computer Graphics. Associate professor at the School of Architecture in Madrid (UPM). Currently professor at the Master in Architectural Communication and the Master in Computational Design (Polytechnic and Complutense Universities of Madrid), and the Master in Product Design at the Superior School of Design of Barcelona. He has taught and guest lectured at several renowned institutions across the world, including the Ecole Polytechnique Fédérale de Lausanne (EPFL) and the Architectural Association in London. Professionally he has collaborated in international projects with studios such as Toyo Ito & Associates, NH Hotels or the City Hall of Madrid., but rather as one of the many that contribute to the collective production of space.